KNOWING THE VALUE OF A MATERIAL: LIFE-CYCLE ANALYSIS WITH GREET

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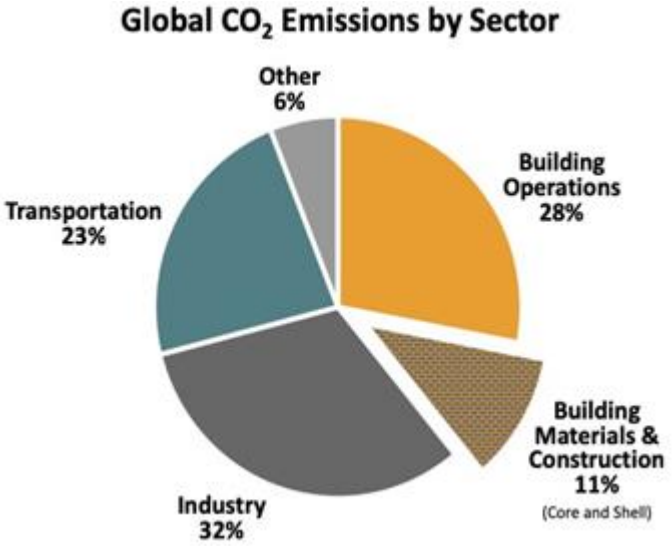
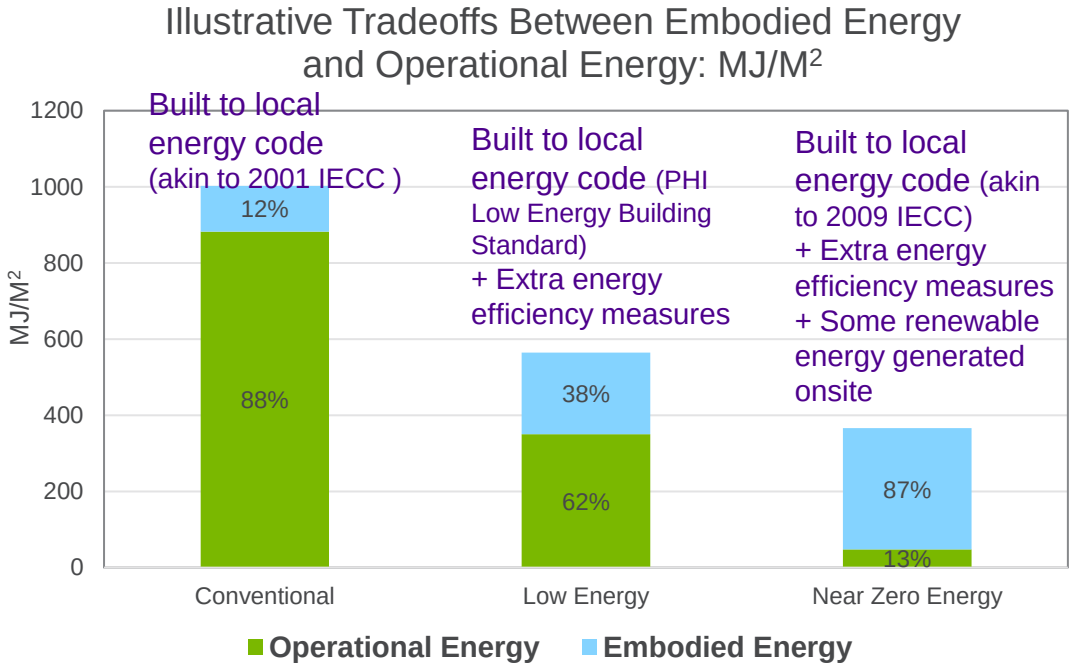
Addressing Embodied Carbon Emissions Is A Key to Addressing Building Sustainability



Source: Architecture 2030

Buildings generate nearly 40% of annual global GHG emissions



Addressing embodied energy/GHGs become an integral part of pursuing net zero energy buildings

- ***Carbon-advantaged materials are a key***

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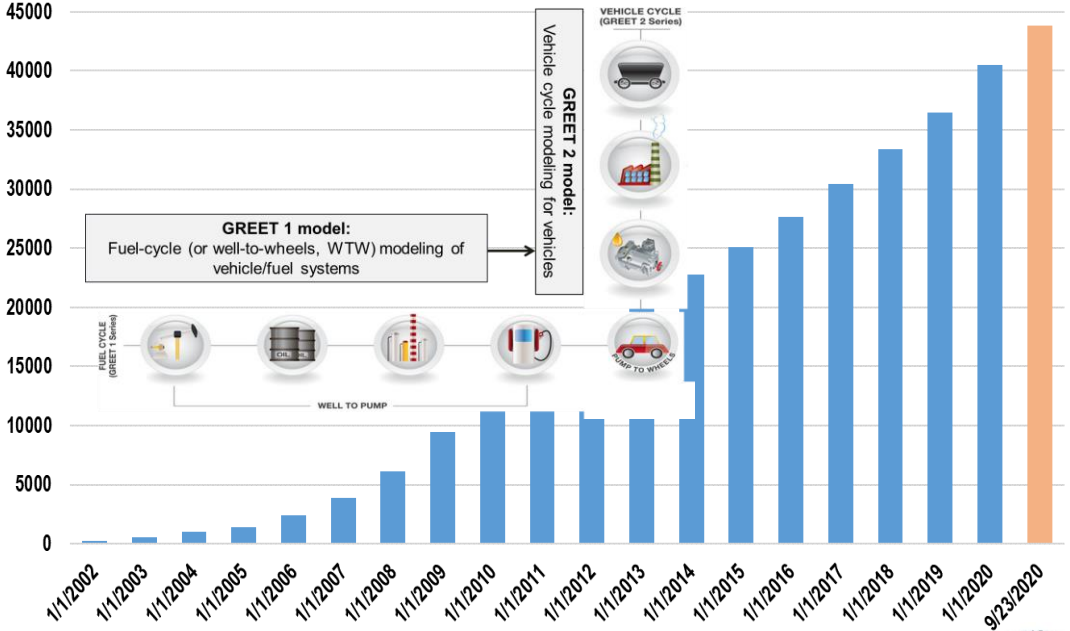
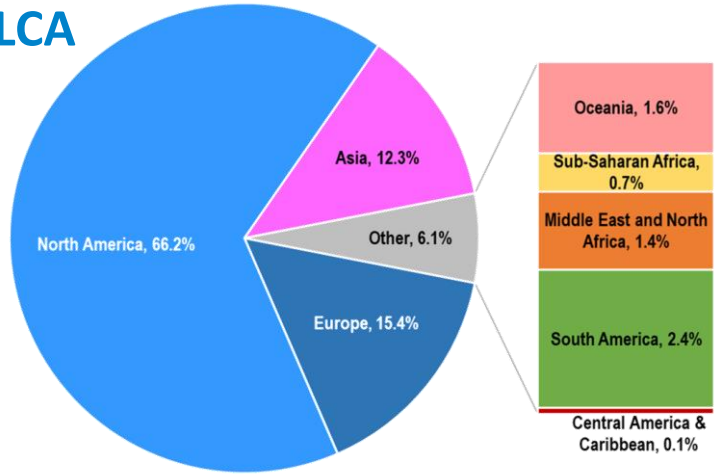
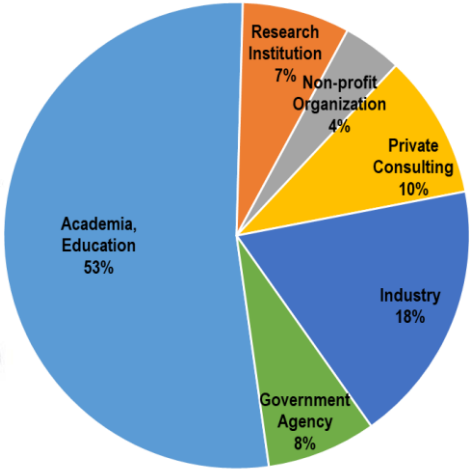
With BTO Support, Argonne Is Expanding Its GREET LCA Model for New Building Technologies and Materials

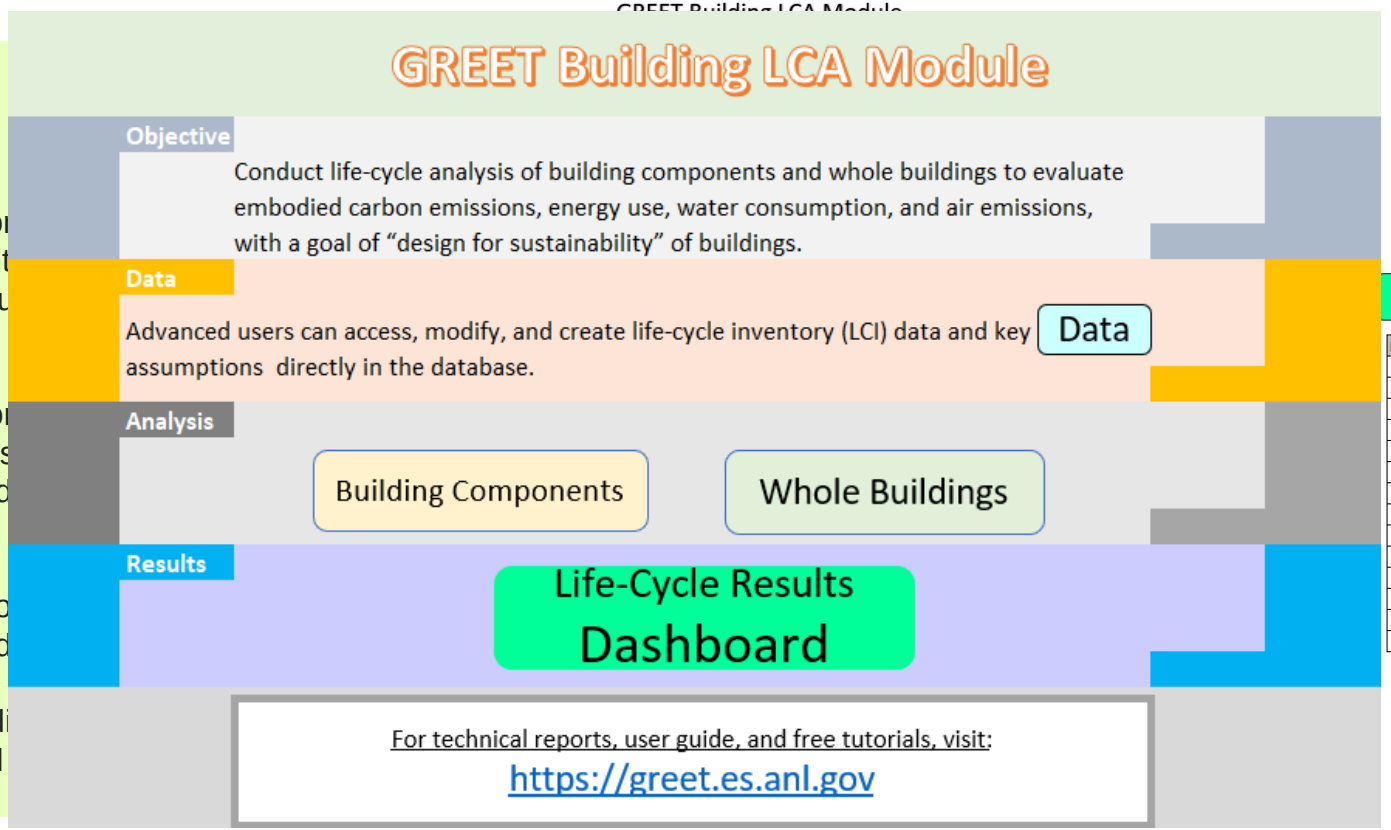




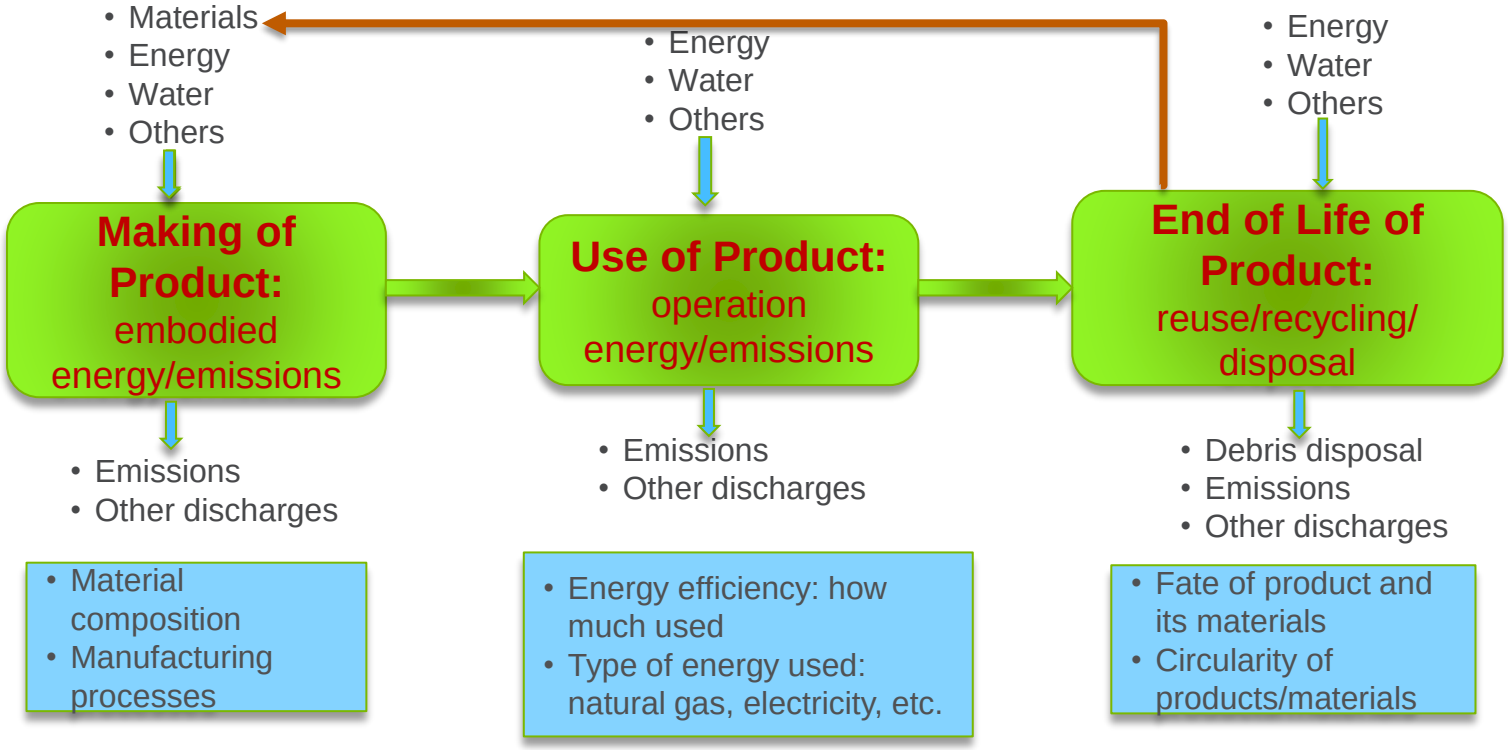


GREET Building LCA Module for Building Materials and Whole Buildings

- GREET Building Module (Beta)
- LCA of selected building insulatio materials to ident hotspot GHG sou
- Expand lifecycle inventory data fo building materials components, and technologies
- Offer guidance fo development and deployment of sustainable build components and technologies



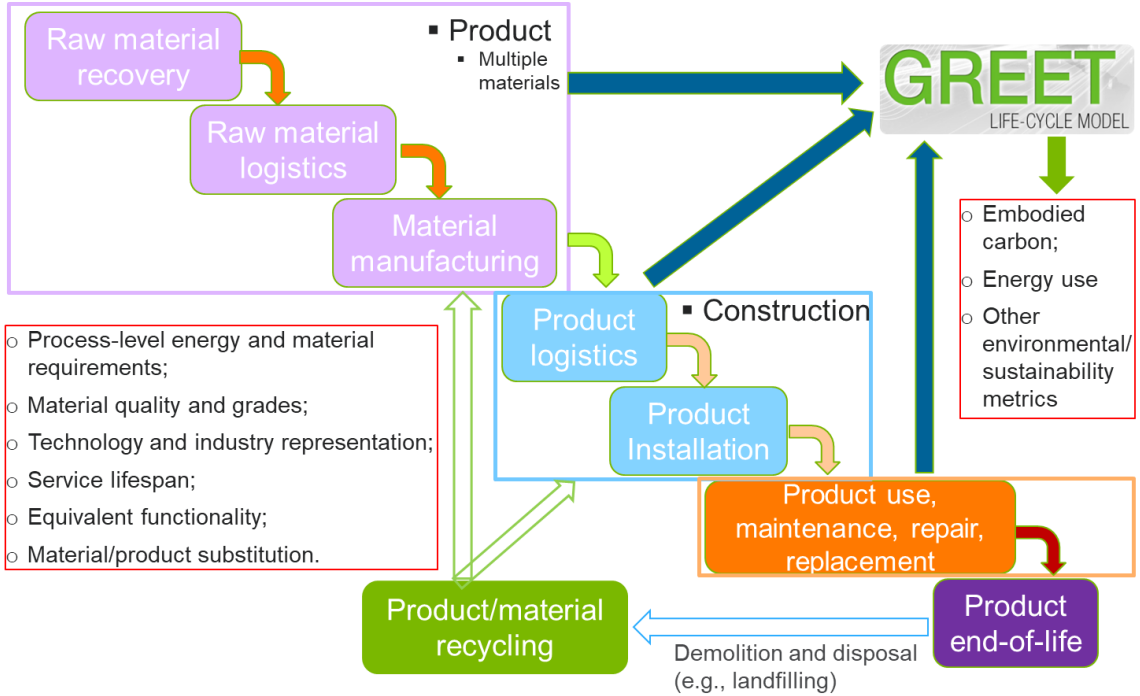
Building LCA: Cradle-to-Grave Consideration of A Building Material to Address Its Energy and Environmental Footprints



All inputs (materials, energy, and water) have their own life cycles and footprints!

GREET Building LCA Methodologies

- ***Thorough, consistent LCA methodologies***
  - Clearly defined and consistent system boundary
  - Defining and using a performance-equivalent functional unit is key to comparable LCA among building technologies



Data is Key to Detailed and Reliable LCA: Data sources for GREET building LCA

Extensive GREET background data for materials and processes

- Process energy such as natural gas and electricity
- Process materials/chemicals such as acid, base, plastics

Industry engagement

- Building material manufacturers and technology developers: NAIMA (insulation), Gypsum Board Association, ARMA (asphalt singles), AISI (steel), Vinyl Siding Institute, EPS Industry Alliance, Kingspan (VIP)

Open literature and results

- Journal articles
- Industry studies/reports
- Manufacturer EPDs

Engineering modeling

- **Process engineering modeling with Aspen-Plus for new materials and processes**
- Leveraging building energy models and building technology performance assessment for equivalent service functions

DOE and other agencies R&D results

- **ABC teams for new building technologies**
- EERE transportation programs on steel, aluminum, foam products, etc.
- NIST of Commerce Department

Leverage other LCA studies/models

- Literature
- Building LCA models, e.g., BEES, Athena Impact Estimator

Working with building technology developers and stakeholders, Argonne develops foreground data for LCA:

- **Material requirements and manufacturing processes**
- **Supply chains, recycling, and reuse of materials**
- **Quality and performance attributes**

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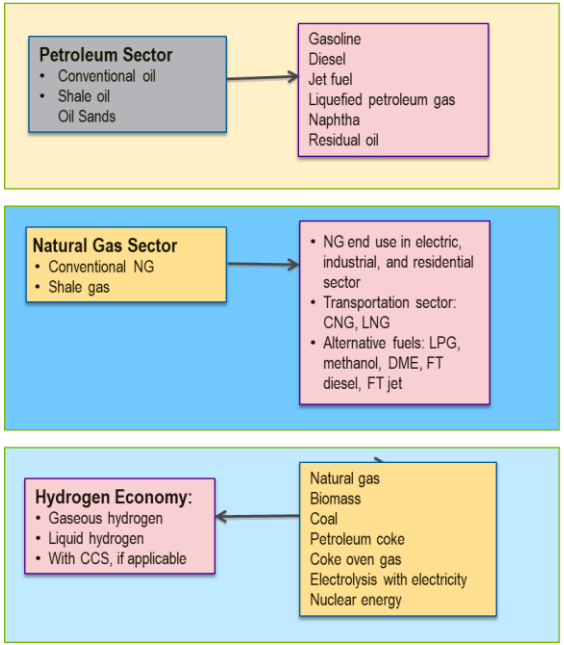
GREET Building LCA Leverages Extensive Coverage and Data in GREET



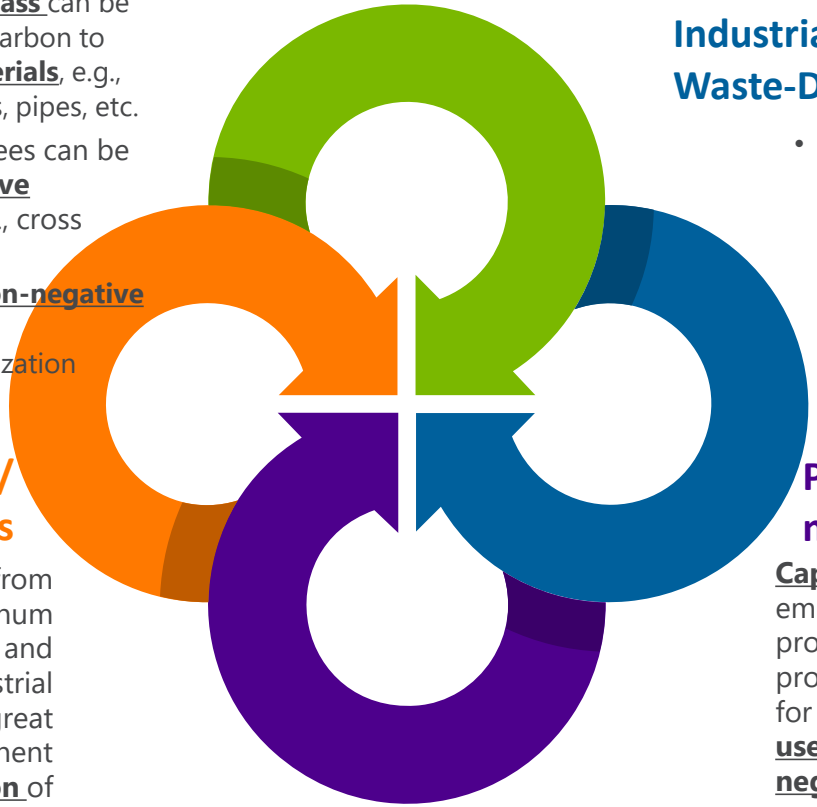
- GREET covers five energy sectors and >60 material groups
- GREET biomass and bioproduct LCA can be leveraged to address emerging carbon negative materials
- iled LCI data have been developed for these sectors and materials

Material Type	Number in GREET	Examples
Ferrous Metals	3	Steel, stainless steel, iron
Non-Ferrous Metals	12	Aluminum, copper, nickel, magnesium
Plastics	23	Polypropylene, nylon, carbon fiber reinforced plastic
Vehicle Fluids	7	Engine oil, windshield fluid
Others	17	Glass, graphite, silicon, cement
Total	62	

Existing Carbon Sources Offer Ample Opportunities for Potentially Carbon-Negative Building Materials

Biomass-Based Materials

- **Short-rotation, fast growing biomass** can be a promising source of sequestered carbon to produce **low-carbon building materials**, e.g., insulation materials, carpet materials, pipes, etc.
- Long-term softwood/hardwood trees can be feedstock for ideal, **carbon negative structural building materials**, e.g., cross laminated timber (CLT)
- It offers potentials to produce **carbon-negative materials** when carbon sequestration/storage/recycling/utilization strategies are deployed.



Industrial/Municipal Waste-Derived Materials

- **Recycle, remanufacturing, and reuse** carbon-rich industrial and municipal wastes, such as textile, concrete/asphalt, alkaline solid wastes, biochar **shift waste carbon sources from landfill,** which may lead to negative GHG emission impacts, **to a carbon sink as building materials.**

Carbon-Absorption/ Mineralization Materials

Rock and mud-like wastes from mining, cement and aluminum production, coal burning, and other large-scale industrial processes present great potentials for permanent **absorption/mineralization** of ambient CO_2 emissions.

Pulling CO_2 from the air/ manufacturing processes

Capturing CO_2 emissions from the air and emission-intensive manufacturing processes such as the clinker production process for cement production opens door for utilizing the otherwise emitted CO_2 **as a useful building block to produce carbon-negative building materials**.

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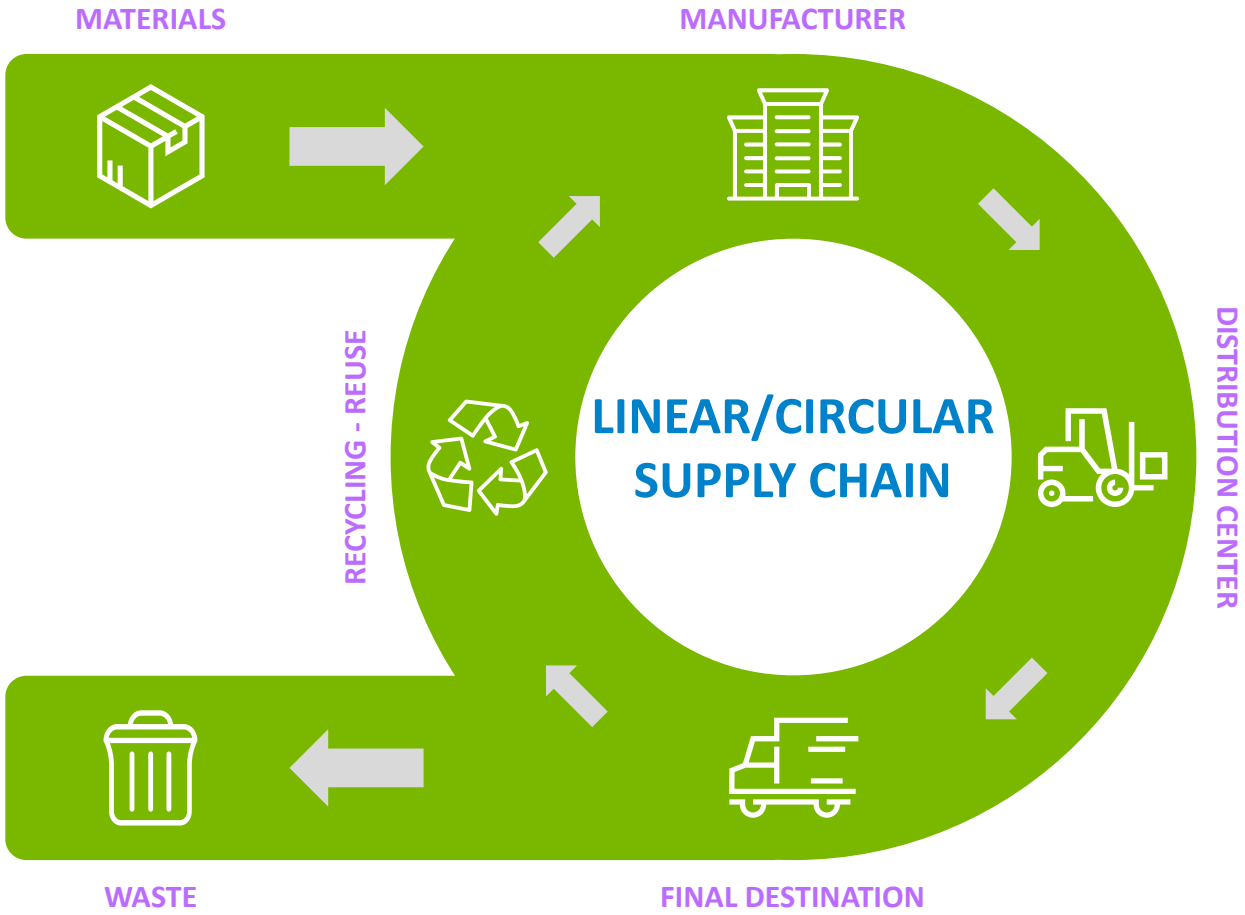
Life-Cycle Analysis Is Needed to Understand the Carbon Value of Emerging Carbon Negative Building Materials



- Direct carbon
  - Process energy
  - CO_2 sequestration
  - CO_2 release during use phase and end-of-life
- Indirect carbon
  - Material inputs
  - Logistics
  - CO_2 absorption
  - CO_2 mineralization
- Key issues
  - Supply chain energy/material balances
  - Carbon source
  - Carbon fate
  - Recycled carbon
  - Shifted paradigm (avoided counterfactual impacts)

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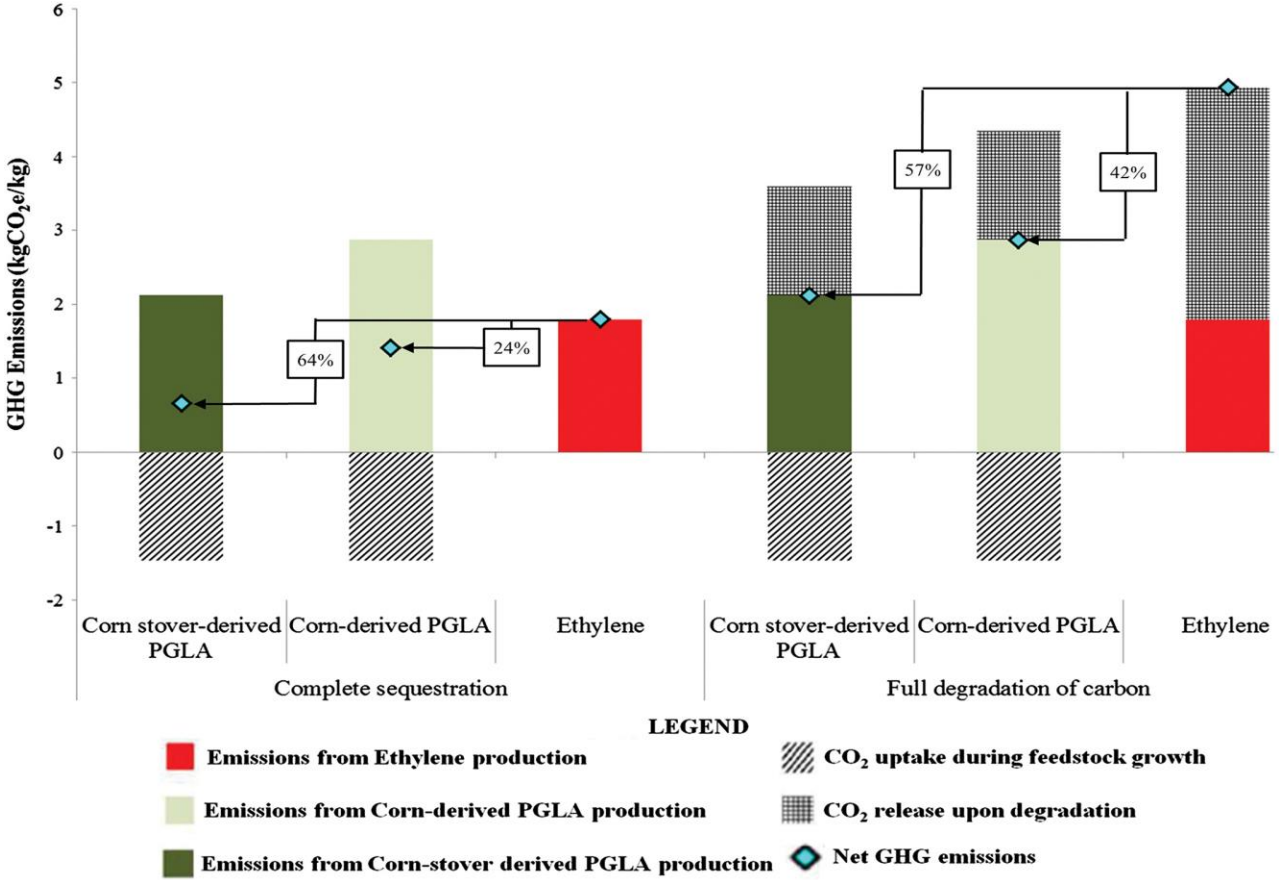
GREET Life-Cycle Analysis Develops Knowledge About the Carbon Value of Materials Made of Carbon-Negative (Biogenic Carbon) Sources

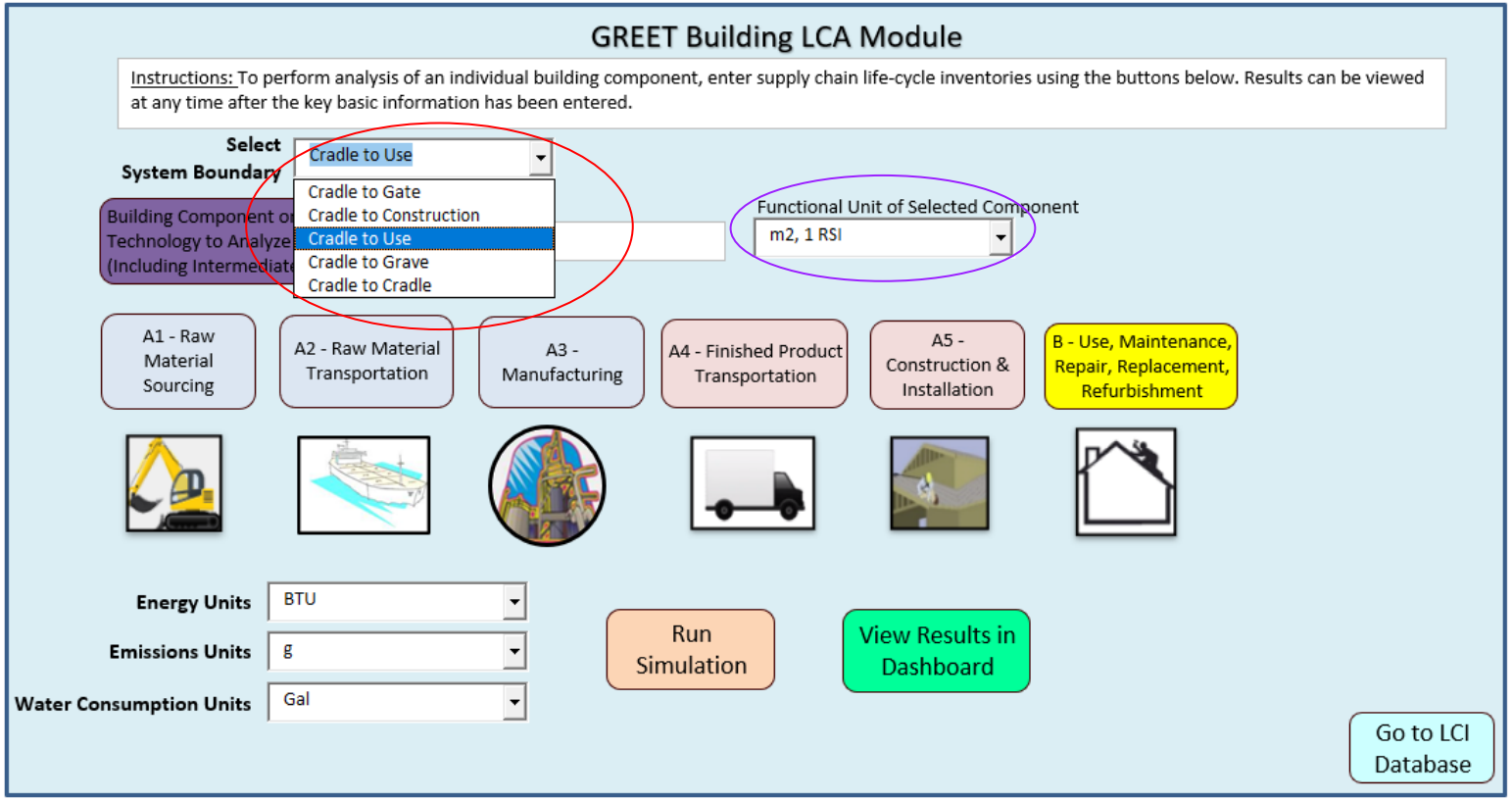


- Negative carbon feedstock (e.g., biomass) holds promises for great carbon benefits relative to fossil carbon feedstocks (e.g., natural gas).
- LCA illuminates life-cycle carbon value of materials made of carbon-negative sources and identifies opportunities to mitigate embodied carbon impacts.

Adom and Dunn, 2016

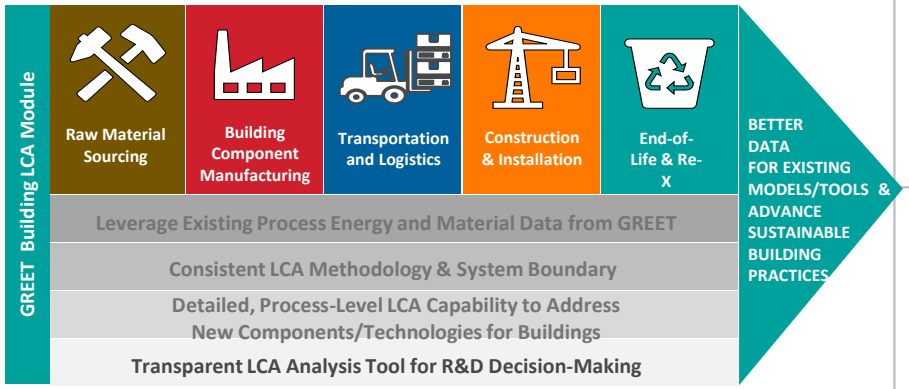
The GREET building LCA module is Used to Address Insulation Materials

- LCA methodology is developed
- The GREET building LCA module architecture was designed with interactive features



Working Together, Argonne Life-Cycle Analysis Aims to Inform Carbon Values of Building Technology Research and Development for Deep-Decarbonization of Building Materials

Lifecycle Analysis (LCA) Modeling Tool to evaluate impact of embodied carbon/energy of buildings and to inform agency research investments to advance sustainable building technologies and practices.



- Beta-Version of GREET Building LCA Module
- Life-Cycle Analysis of selected building insulation materials to identify hotspot GHG sources

Addressing embodied carbon/energy impacts of building materials and construction, accounting for 11% of carbon emissions worldwide

As building energy efficiency improves, addressing embodied energy/carbon of building materials becomes more critical for building decarbonization.

NEW DEVELOPMENTS

- **Assist BTO ABC FOA Teams with embodied carbon analysis of their technologies**
- **Expand Lifecycle Inventory data for new building materials, components, and technologies**
- **Offer guidance for development and deployment of sustainable building components and technologies**

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WE START WITH YES,

WE END WITH THANK YOU.

Questions & Feedback?